INFLUENCE OF MATURITY AND FRUIT YIELD ON SUSCEPTIBILITY TO LEAFSPOT DISEASES OF PEANUTS (*Arachis hypogaea* L.)

By

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Three peanut, Arachis hypogaea L., cultivars were evaluated for amount of leafspot diseases and yield. The objectives of this experiment were to examine the relationship of yield and maturity to susceptibility to leafspot diseases in peanuts.

The three cultivars, Early Bunch, Florunner, and Dixie Runner, differing in yield and maturity were grown two years at Gainesville, Florida. To further regulate reproductive efficiency, the initial floral buds were removed from half the plots. Additionally, the experiment was divided into two blocks with one receiving fungicidal spray.

Removing the initial floral buds appeared to reduce the amount of leafspot disease and extend maturity for all cultivars in both sprayed and unsprayed blocks. Leaf retention was greater for Early Bunch and Florunner plots with controlled reproductive efficiency than corresponding plots with unrestricted flowering in 1979. Dixie Runner

showed little difference between reproductive treatments. Lesion numbers per plot sample in 1980 indicated a similar response to controlling reproductive efficiency. The two higher yielding cultivars had fewer lesions in the plots with restricted flowering than those with uncontrolled reproductive efficiency.

Pod yield of Early Bunch, the highest yielding cultivar, was reduced most by floral bud removal. The yield of Florunner was reduced slightly and that of Dixie Runner the least. Mean yield and leafspot disease differences due to flower removal were greater in the unsprayed block.

These experiments indicate that reducing the initial fruiting of peanut plants reduces the amount of leafspot disease and based on leaf retention, delays plant maturity. Also, that cultivars respond differently to flower removal relative to yield and to leafspot disease control.

INTRODUCTION

The costs of producing peanuts (Arachis hypogaea L.), both economically and environmentally, are increasing greatly. A part of these costs is involved with controlling leafspot diseases which occur wherever peanuts are grown. Resistance to these diseases would, therefore, contribute to the production of peanuts throughout the world. Peanut breeders have observed great variability in resistance within the genus from almost immunity to high susceptibility. However, the most resistant lines have been in species other than the cultivated peanut.

Within the cultivated species of peanut very little variability has been found. A number of characteristics may be involved with the degree of resistance in a particular peanut cultivar or line. Late maturing, spreading or semi-bunch types with large green leaves that have low yields have been more resistant. The inability to develop high yielding, resistant cultivars also associated low yield with resistance. Additionally the size of stomatal apertures has been shown to affect susceptibility.

The objective of this research was to examine the relationship of yield and maturity to susceptibility to leafspot diseases in three peanut cultivars.

LITERATURE REVIEW

Leafspot diseases of peanuts occur throughout the world in almost all peanut production areas. Losses due to these diseases range from 10% to 50% when adequate control measures are not taken. Berkeley (1875) first described the pathogens which incite these diseases as Cladosporium personatum. The classification of these pathogens varied for about 45 years until specimens and reports were compared, and Woodroof (1933) determined that there were two species of Cercospora inciting the leafspot disease. The two pathogens were identified as Cercospora arachidicola Hori and Cercospora personata (Berk. and Curt.) Ellis and Everhart. Jenkins (1938) identified the perfect stages of Mycosphaerella arachidicola and Mycosphaerella berkeleyii. Deighton (1967) recently transferred Cercospora personata to the genus Cercosporidium naming it C. personatum.

The pathogens overwinter on crop debris on the soil (Hemingway, 1954; Kucherek, 1975; Wolf, 1916) or on volunteer plants (Hemingway, 1954). Leaves infected with these pathogens fall to the ground. Mycelia persist in the diseased leaves for six months or more and upon favorable conditions the following year, readily sporulate producing inoculum for the initial disease cycle of that season. Conidia are also thought to persist from season to season (Hemingway, 1954). The sexual stage of these pathogens is reported to be a survival structure (Jenkins, 1938; Woodroof, 1933) but is not considered to be important in nature.

Conidia are splashed from the soil to the leaves of young peanut plants by rain, blown from sporulating lesions by wind (Hemingway, 1954) or transmitted by insects (Wolf, 1916). Conidial germination occurs when the temperature is within the range of 20° C to 30° C, and the air is nearly saturated with a relative humidity of 96.5% or more (Jenson and Boyle, 1965, 1966). Germination may occur from one or more of the conidial cells within three to eight hours (Jenkins, 1938). Abdou et al. (1974) found 95% to 99% of the conidia germinated 48 hours following inoculation under controlled conditions. Germ tubes of both pathogens have been reported to penetrate the epidermal cell walls (Jenkins, 1938), but further observations showed that most entered through open stomata (Abdou et al., 1974; Jenkins, 1948) about six days after inoculation. Abdou et al. (1974) reported germ tubes appeared to be attracted to open stomata in some peanut lines. In both pathogens the distal ends of the germ tubes enlarged and penetration pegs formed entering the stomata.

Following penetration, secondary mycelia formed. Cercospora arachidicola produced intercellular hyphae at first; and then, following the death of the cells in advance of the growing mycelia, cell walls were penetrated (Abdou et al., 1974; Jenkins, 1938; Woodroof, 1933). The secondary mycelia of C. personatum grew intercellularly with the production of haustoria, and the cells were not killed in advance of the growing hyphae. As the mycelia spread in the host tissue, cells collapsed and produced the necrotic spot (Abdou et al., 1974; Jenkins, 1938). Lesions caused by C. arachidicola usually were surrounded by pale yellow halos in early stages while halos formed around mature lesions of C. personatum (Jenkins, 1938; Woodroof, 1933).

Both pathogens produced stromata, often in the stomatal chambers. Differences between stromatal development of the two pathogens were shown. Stroma developed on the lower or on both surfaces of C. personatum lesions but primarily on the upper surface of C. arachidicola lesions (Abdou et al., 1974; Jenkins, 1938; Woodroof, 1933). Under favorable conditions the stroma produced conidiophores about two weeks following infection (Abdou et al., 1974). The conidiophores emerged through the stomata or ruptured the epidermis.

Early research (Woodroof, 1933), showing that the pathogens overwintered in peanut residues, suggested the measures first used to control these diseases: sanitation and crop rotation. Burning and deep plowing all residues were recommended (Hemingway, 1954). Wolf (1916) found that rotation by itself reduced but did not eliminate leafspot. Hemingway (1954) suggested at least two years between crops of peanuts on the same land. Mazzani and Allievi (1971) found great differences between fields of peanuts grown consecutively for seven years and those with six years fallow between crops. Plants in the fields grown continuously in peanuts had about 45 lesions on 100% of their leaves, while those plants which were grown with six years fallow between crops averaged about two lesions on 52% of the leaves. In addition, plant life was lengthened 20 days, yield increased 70%, and fruit and kernel weight and kernel percentage were greater for the crop grown in rotation. Kucharek (1975) reported that a one year rotation reduced the number of lesions per leaflet about 90%

during the early growing season. This reduction occurred in adjacent fields, one under rotation, the other not. Differences existed whether or not fungicide control was used.

Planting time has been shown to affect the amount of leafspot occurring in a particular crop. Delaying planting decreased leafspot occurrence in a study in Africa (Farrell et al., 1967) and in India (Nath and Kulkarni, 1967). In Africa and India the later plantings develop in dryer environments and are lower yielding, whereas in the southeastern United States later plantings are frequently exposed to higher humidity and often show greater disease.

Farrell et al. (1967) also showed that decreasing plant density decreased leafspot diseases. The authors suggested two possible reasons for the reduction in lesion number. First, with higher densities or narrow spacings, the leaf canopy is tighter increasing the moisture retained within the canopy. High humidity is one of the requirements for germination and infection by the spores. Secondly, there is a dilution effect with the wide spacings, in that the plants produce more leaves and, therefore, with equal infection have fewer lesions per leaf. Reducing row spacing to increase yield was effective only when fungicides were used.

Fungicides have been the only effective means of controlling leafspot throughout the growing season. Initially sulfur dust was used in the United States, but in other areas the use of fungicides was not considered economically feasible until higher yielding cultivars and better fungicide application methods were developed (Hemingway, 1954). It was shown that fungicide effectiveness was greater at higher densities or narrow spacings (Farrell et al., 1967). Present

recommendations are to apply fungicides every 10 to 14 days beginning four to eight weeks after planting with four to six applications during the growing season.

A large number of organic fungicides have replaced the sulfur-copper dusts and sprays originally used to control leafspot. Sulfur is sometimes added to these fungicides to improve their efficiency. In 1973 races of both C. arachidicola and C. personatum were found to be tolerant to a fungicide (benomyl) used extensively in the control of leafspot (Backman et al., 1977).

The cost of controlling leafspot diseases with fungicides is rapidly increasing and some of the chemicals may pose a threat to the environment. It has also been shown that the fungicides affect kernel quality by upsetting the balance of pathogenic fungi and their antagonists (Backman et al., 1977; Hammond et al., 1976). Additionally, they found that other pathogens were influenced through leafspot control using fungicides. The frequency of white mold, Sclerotium rolfsii, was greater with the use of some chemicals.

Producing high yielding cultivars that are also leafspot resistant has not been accomplished thus far. Genotypes with useful levels of resistance have been reported (Abdou et al., 1974; Aulakh et al., 1972; Hassan and Beute, 1977; Hemingway, 1954; Nur and Ibrahim, 1968; Sowell et al., 1976; Monasterious, 1980). However, breeders have been unable to utilize this resistance to date. Higgins (1956) reported that in hundreds of crosses he was unable to combine resistance to leafspot and high yield, and that there was a positive correlation between susceptibility to leafspot and maturity.

Hemingway (1954) assessed 75 peanut cultivars for resistance to leafspot diseases and found 25 that showed some resistance. The following year these resistant cultivars were evaluated, and the four that were determined to be very resistant had dark green foliage, were longer season cultivars, and had bunch or semi-bunch growth habits. Other studies (Aulakh et al., 1972; Nur and Ibrahim, 1968) found that spreading and semi-bunch types were significantly more resistant than bunch types. Sowell et al. (1976) examined 1400 plant introductions and found three that had significantly less disease than the susceptible cultivars included in the test. The yield of these plant introductions were also significantly lower than the cultivar, Florunner, and the maturity significantly later. Mazzani et al. (1972) found that of the 474 lines they evaluated, the lines which had large yields had high disease incidence. Positive relationships between light green foliage and large leaves with high disease also were shown.

Gibbons and Bailey (1967) associated resistance to leafspot diseases with small stomatal apertures. Mazzani et al. (1972) and Hasson and Beute (1977) found no relationship between aperture size and resistance among the lines they studied. Abdou et al. (1974) reported that the germination tubes were attracted to the stomatal openings in susceptible lines but not to the stomata of resistant lines. Results from their study led to the conclusion that the cultivated species of Arachis did not contain useful levels of resistance to leafspot diseases. Several other species within the genus show high resistance or immunity to the leafspot pathogens. The wild relatives of the cultivated peanut that showed this resistance

were dark green, produced few if any fruit and were either very late maturing or perennials.

Many plant diseases have been associated with some factor of plant nutrition. Bledsoe et al. (1946) examined the effects of several nutritional deficiencies (phosphorus, potassium, calcium, magnesium, sulfur, and several micronutrients) on the peanut plant. Of all these, only plants with deficiencies in magnesium showed leafspot disease more severe than the controlled plants. Magnesium deficiency symptoms became apparent 24 days after magnesium was withheld from the plant. Four days later lesions of C. arachidicola appeared on the leaves which showed the first magnesium deficiencies. Progress of the disease continued following the same development as that of the magnesium deficiency.

The disease of the plants growing in magnesium deficient soil developed while the plants were producing fruit. Magnesium deficient plants produced more flowers and gynophores than those in any other mineral deficient soil. It has been shown that the fruit may take up calcium from the soil (Bledsoe and Harris,1950), and that its application in the form of gypsum increases both the production of fruit and the plants susceptibility to leafspot. Much of the magnesium in the leaves of the magnesium deficient plants was mobilized and transported to the gynophores and fruit, greatly lowering the percentage magnesium in the leaves compared to those in soil with no added nutrients. Burkhart and Collins (1941) reported that magnesium is also concentrated in the kernels. This may explain why production of a large number of fruit could increase the susceptibility of peanut plants to leafspot diseases.

Whether or not reduced magnesium in the leaves is the direct or indirect cause of susceptibility to leafspot has not been determined. Bhagsari and Brown (1976) showed that cultivated peanut lines translocated more of the photosynthetically assimilated ^{14}C than did wild relative species. Smith (1954) reported that production of flowers and gynophores is inhibited by an increasing number of developing fruit.

These reports, plus observations that leafspot disease symptoms in the field generally are first noted at flowering, suggest that leafpot disease susceptibility may indeed be related to reproduction. It appears that the fruit may withdraw some substance from the vegetative plant parts which induces susceptibility to leafspot and the larger the sink, i.e. fruit set, the greater the susceptibility.

MATERIALS AND METHODS

The experiments reported here were grown during 1979 and 1980 as randomized, complete block designs with six treatments. In 1979 the field plots were on the Green Acres Agronomy Farm, Gainesville, Florida, and in 1980 on the University of Florida Campus Agronomy Farm, Gainesville, Florida. Cultural practices during both years were those recommended for commercial peanut production. Rainfall was augmented with irrigation to maintain adequate moisture for plant growth, and fertilizer was applied at recommended levels prior to planting. Two applications of gypsum were made each year after flowering had commenced. Weeds were controlled through the use of herbicides and hand cultivation.

In 1979, plots were one row 6.1 m (20 ft) long with 30 cm (1 ft) between plants and 91 cm (3 ft) between plots. Plots were 4.3 m (14 ft) long in 1980 with all other spacings the same as the previous year. The experiment was divided into two blocks, one received fungicidal spray for leafspot control, and the other remained untreated for the duration of the experiment. The treatments were replicated within each spray regime four times.

The six reproductive treatments consisted of three cultivars: high, moderately high, and low yielding, each with a plot in which the reproductive efficiency was controlled until peak flowering and a control plot with unrestricted flowering. The three cultivars differed

in yield, days to maturity, and peak flowering (Table 1). Early Bunch, the highest yielding cultivar, has the shortest maturity. Florunner has a moderately high yield and intermediate maturity. Dixie Runner is the lowest yielding and latest maturing of the three cultivars.

The reproductive efficiency was controlled by removing floral buds prior to fertilization. The majority of the floral buds were removed from 1900 hours (7:00 P.M.) until 2300 hours (11:00 P.M.) daily after they had enlarged, and the peanut leaflets had folded together. The remainder were removed the following morning prior to 0930 hours (9:30 A.M.) to insure that fertilization had not occurred. The number of plants in which the reproductive efficiency was controlled decreased from 20 plants per plot initially to five plants per plot because it was too time-consuming to remove all the flowers from 20 large plants.

Seeds were planted by hand in mechanically opened furrows. The first experiment was planted 2 May 1979 and the second experiment 1 June 1980. Upon emergence, plantings were thinned to one plant per 30 cm. Plants began flowering about 30 days after planting both years. Floral bud removal began with the first flowers and continued until 76 days, 83 days, and 90 days after planting for Early Bunch, Florunner, and Dixie Runner, respectively.

The relative amounts of leafspot disease for each plot were estimated in 1979 by visual leaf retention ratings on 17 September prior to the second harvest of Early Bunch. A one to five rating scale was used with one being totally defoliated and five retaining a full canopy. In 1980 samples of 10 leaves were chosen randomly from each plot at

Table 1. Relative yielding ability, maturity, and peak flowering of the three cultivars used in this experiment.

Cultivar	Relative Yield	Maturity*	Peak Flowering*
Early Bunch	High	125 - 130	78
Florunner	Mod. High	135 - 140	83
Dixie Runner	Low	140 - 145	90

*Days from planting.

10 day intervals and the number of lesions counted to assess the severity of disease.

Plots were harvested at the average physiological maturity for the respective cultivars and again 15 days later. Early Bunch was harvested at 125 and 140 days after planting, Florunner at 135 and 150 days, and Dixie Runner at 145 and 160 days after planting. Plants were loosened from the soil with a potato fork and then lifted and picked by hand. After the plants were removed, the soil was sifted to gather any remaining pods. After harvest the fruit samples were dried, weighed, and graded following standard Federal-State Inspection Service grading procedures.

The least significant differences (LSD) in the following analysis of variance tables are appropriate for comparing the treatment means. However, since variation depends on the size of the mean, different LSD values are needed to compare two small means than to compare two large means. Additionally, because of restraints on the field layout of this experiment no test is possible for spray regime main effect differences.

RESULTS

Means for leaf retention ratings, number of lesions per plot, pod yield, percent sound mature kernels and sound mature kernel yield are presented in Tables 2, 4, 6, 8, and 10, respectively. The corresponding analysis of variance are presented in Tables 3, 5, 7, 9, and 11. Graphs of the mean lesion number per plot for Early Bunch, Florunner, and Dixie Runner are shown in Figs. 2, 3, and 4, respectively.

Leafspot Measurements

Cercospora arachidicola lesions appeared as the plants began flowering about 30 days after planting in 1979. This disease, however, was present for only a short time, even in the unsprayed plots. *Cercosporidium personatum* lesions were first observed about 85 days after planting corresponding to approximately peak bloom for the three cultivars. Development of *C. personatum* progressed at about the same rate on all plots for 14 days, after which time visual differences were seen between the plots in which the floral buds had been removed and those with uncontrolled flowering.

Leaf retention ratings (Table 2) indicate that bud removal had a large effect on the high and moderately high yielding cultivars, and a lesser effect on the low yielding cultivar. Analysis of variance (Table 3) showshighly significant ($P<0.01$) differences

Table 2. Mean effect of fungicidal spray and removal of flower buds on leaf retention ratings of three peanut cultivars 135 days after planting in 1979.

Cultivar	Treatment	Rating*
Early Bunch	Spray - Flower buds removed	3.5
	" - Control	2.0
	No spray - Flower buds removed	2.7
	" - Control	1.5
Florunner	Spray - Flower buds removed	3.7
	" - Control	3.0
	No spray - Flower buds removed	3.0
	" - Control	2.5
Dixie Runner	Spray - Flower buds removed	4.0
	" - Control	3.7
	No spray - Flower buds removed	3.0
	" - Control	3.0
LSD .05		0.8

* 1 = No leaves; 5 = Full canopy; data represents mean of four ratings.

Table 3. Analysis of variance for the effect of fungicidal spray and removal of flower buds on leaf retention ratings for three peanut cultivars in 1979.

Source of Variation	df	Mean Squares
Spray regimes (S)	1	6.0
Replications within spray regimes	6	2.6**
Reproductive treatments (T)	5	3.5**
S x T	5	0.1
Error	30	0.6

** Significant at the 0.01 level of probability.

among the six reproductive treatments. Leaf retention ratings were higher for the lower yielding cultivars and under the spray regime.

Leaf retention ratings for Early Bunch, the high yielding cultivar, were significantly ($P<0.05$) improved by flower-bud removal and fungicidal spray, 3.5 compared to 1.5 (Table 2). Ratings were improved by the floral removal treatment in both the sprayed and unsprayed plots. However, the ratings for the plots with unrestricted flowering in the sprayed block were not significantly different from those of the plots with restricted flowering in the unsprayed block.

Florunner, the moderately high yielding cultivar, showed similar differences between reproductive treatments and spray regimes. Unsprayed plots with uncontrolled reproductive efficiency showed significantly ($P<0.05$) less leaf retention than the sprayed plots with bud removal. All other comparisons for this cultivar were not statistically different.

Leaf retention ratings for Dixie Runner, the low yielding cultivar, ranged from 4.0 for the controlled reproductive efficiency plots in the sprayed block to 3.0 for both reproductive treatments in the unsprayed block. The only significant difference in ratings was between these extremes, with both not significantly different from the sprayed plots with uncontrolled flowering.

Dixie Runner with uncontrolled flowering and no fungicide spray retained as many leaves as the higher yielding cultivars with controlled flowering and fungicide sprays. In both the sprayed

and unsprayed blocks the three cultivars with controlled reproductive efficiency showed no significant ($P<0.05$) differences in leaf retention. F tests showed that spray regimes were not significantly different nor were there significant spray regime by reproductive treatment interactions.

Figure 1, a photograph taken 135 days after planting in 1979, shows that where the floral buds were removed leaves were retained almost uniformly in all the cultivars (the green area appearing horizontally across the three cultivars in the photograph). However, where flowering was not controlled, Early Bunch, Florunner, and Dixie Runner lost progressively fewer leaves in that order.

The summer of 1980 was very dry and the peanut leafspot diseases were late. Only a few C. arachidicola lesions were found relatively late in the season. Again, there was no build-up of this pathogen and, as in 1979, it soon disappeared. Cercosporidium personatum began to show up about 80 days after planting, and with a brief period of rain the population increased very rapidly in the unsprayed plots. Following another period of dry weather the number of lesions per plot decreased from 30 August to 10 September and then increased again until a maximum of about 750 lesions per plot sample was reached. There were highly significant ($P<0.01$) differences among reproductive treatments and spray regimes by reproductive treatment interactions at all sampling dates (Table 5).

Fig. 1. Photograph of the six reproductive treatments in the sprayed block of the 1979 experiment 135 days after planting.

On the first sampling date (20 August 1980--Table 4), no significant differences were found in the sprayed block. In the unsprayed block where the number of lesions was much greater, significant ($P<0.05$) differences are shown only between reproductive treatments of the high yielding cultivar and between the high yielding cultivar and the other lower yielding cultivars. In the sprayed block the lesion numbers per plot sample ranged from 10 for Dixie Runner with controlled flowering to 66 for Early Bunch with uncontrolled flowering. In the unsprayed block the range was from 129 for Florunner with buds removed to 699 for Early Bunch with unrestricted flowering. The variation among samples within a plot was large as reflected by the least significant difference.

Lesion numbers increased from the first to the second sampling for the reproductive treatments of Early Bunch in the unsprayed blocks. Early Bunch had significantly ($P<0.05$) more lesions than the other two cultivars. Number of lesions per plot in the sprayed block ranged from 19 for Dixie Runner with controlled reproductive efficiency to 90 for Early Bunch with uncontrolled flowering. In the unsprayed blocks the range was from 254 to 766 for Florunner with controlled reproductive efficiency and Early Bunch with uncontrolled flowering, respectively. Variation within samples at the second sampling date was less than at the first.

The number of lesions per plot on the third sampling date was reduced relative to the first two sampling dates, particularly in the unsprayed block. Differences between treatments within blocks were small and insignificant statistically, except for the Early Bunch reproductive treatments in the unsprayed block which were different ($P<0.05$) from each other and from the other treatments.

Table 4. Mean effect of fungicidal spray and removal of flower buds on the number of lesions per plot sample (10 leaves) at 10 day intervals for three cultivars in 1980.

Cultivar	Treatment	Date				
		8/20	8/30	9/10	9/20	10/10
Early Bunch	Spray - Flower buds removed	66	71	25	113	653
	" - Control	57	90	40	240	761
	No spray - Flower buds removed	699	713	215	531	745
	" - Control	496	766	312	755	763
Florunner	Spray - Flower buds removed	11	22	16	81	350
	" - Control	23	46	21	103	574
	No spray - Flower buds removed	136	254	51	225	483
	" - Control	129	281	56	353	719
Dixie Runner	Spray - Flower buds removed	10	19	10	51	166
	" - Control	20	26	12	122	238
	No spray - Flower buds removed	137	288	62	279	328
	" - Control	200	300	60	357	492
LSD .05		75	43	25	63	78

Table 5. Analysis of variance for the effect of fungicidal spray and removal of flower buds on the number of lesions per plot sample (10 leaves) at 10 day intervals for three peanut cultivars in 1980.

Source of Variance	df	Mean Squares Sampling date				
		8/20	8/30	9/10	9/20	10/10
Spray regimes (S)	1	864,033	1,806,528	133,141	2,650,800	206,981
Replications within spray regimes	6	171,131**	312,168**	22,515**	454,329**	38,265**
Reproductive treatments (T)	5	139,885**	140,983**	29,289**	104,129**	345,329**
S x T	5	94,713**	88,945**	20,389**	40,897**	13,780**
Error	30	8,102	3,127	380	4,426	3,715

* Significant at the 0.05 level of probability.

** Significant at the 0.01 level of probability.

After the third sampling the number of lesions began to increase. On the fourth sampling date lesion numbers in the sprayed plots ranged from 51 for Dixie Runner with controlled reproductive efficiency to 240 for Early Bunch with uncontrolled flowering. In the unsprayed plots, the range was from 225 for Florunner with bud removal to 755 for Early Bunch with unrestricted flowering. More of the treatments were significantly ($P<0.05$) different at this sampling.

In the sprayed block the two treatments of Early Bunch were significantly ($P<0.05$) different from each other, while those of the other two cultivars showed no differences. There were no significant differences among the three cultivars with controlled flowering. Plots of Early Bunch which had uncontrolled reproductive efficiency had significantly more lesions than those of the other cultivars treated similarly.

In the unsprayed plots the reproductive treatments of each cultivar were significantly different. The plots with uncontrolled flowering had significantly ($P<0.05$) more lesions than those in which floral buds had been removed. Again, Early Bunch had significantly more lesions in both reproductive treatments than the other cultivars.

In the final sample many of the treatments were approaching the maximum number of lesions observed. Lesion numbers in the sprayed block ranged from 166 to 761 for Dixie Runner with controlled reproductive efficiency and Early Bunch with uncontrolled flowering, respectively. The same cultivars had similar minimum (328) and maximum (763) lesion numbers, respectively, in the unsprayed block.

Only the plots of Early Bunch from which the flowers were removed in the sprayed block were significantly ($P<0.05$) different

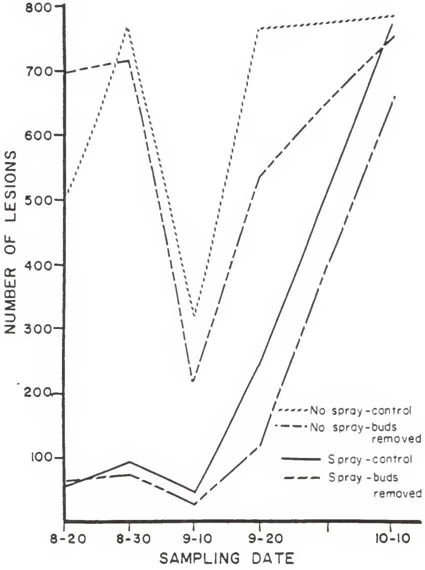

Fig. 2. Graph of the mean effects of flower bud removal and chemical fungicides on the number of lesions per plot sample for Early Bunch in 1980.

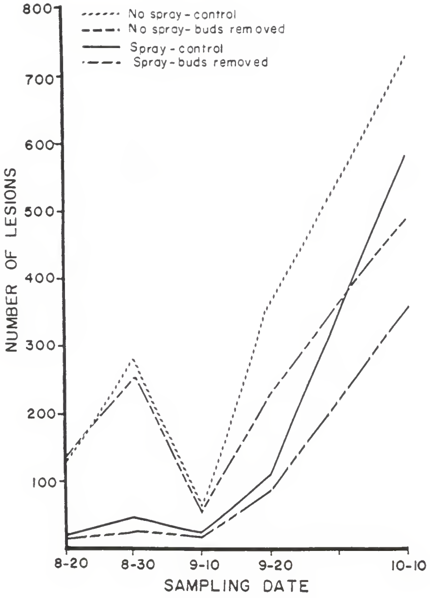

Fig. 3. Graph of the mean effects of flower bud removal and chemical fungicides on the number of lesions per plot sample for Florunner in 1980.

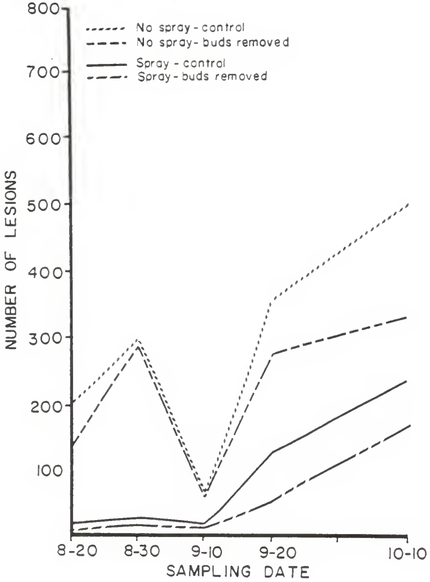

Fig. 4. Graph of the mean effects of flower bud removal and chemical fungicides on the number of lesions per plant sample for Dixie Runner in 1980.

in numbers of C. personatum lesions from the others (Table 4). Florunner plots with controlled reproductive efficiency had significantly fewer lesions than those with unrestricted flowering in both the sprayed and unsprayed blocks. Differences in reproductive treatments of Dixie Runner were significant only in the unsprayed block. Early Bunch treatments had significantly more lesions than the other treatments except for the Florunner plots with uncontrolled reproductive efficiency in the unsprayed block. In the sprayed block Early Bunch had significantly more lesions than Florunner which had significantly more lesions than Dixie Runner.

Graphs plotting the mean C. personatum lesion number per plot sample for the three cultivars presented in Figs. 2, 3, and 4 show similar trends. Fungicidal spray applications resulted in slower increases in pathogen population, but the lesion numbers followed the same general pattern as those of the unsprayed plots. Differences between treatments were greatest when the pathogen population was large, until the population approached maximum size.

A serious occurrence of peanut rust (Puccinia arachidis) caused a large amount of premature leaf abscision throughout the 1980 experiment, irrespective of the treatment, confounding the effects of the leafspot diseases. This prevented obtaining meaningful leaf retention ratings in 1980.

Pod Yield

Data from 1979 and 1980 harvests (Table 6) show the effects of controlling the pathogen population and the reproductive efficiency on yield. Differences among reproductive treatments and the spray regime by reproductive treatment interaction were highly significant ($P<0.01$) in both years.

Table 6. Mean effect of fungicidal spray and removal of flower buds on pod yield (g/plot) for two harvests of three peanut cultivars in 1979 and 1980.

Cultivar	Treatment	1979 Harvest		1980 Harvest	
		First	Second	First	Second
Early Bunch	Spray - Flower buds removed	561	552	534	545
	" - Control	830	820	792	807
	No spray - Flower buds removed	170	174	212	211
	" - Control	446	439	432	445
Florunner	Spray - Flower buds removed	628	641	528	584
	" - Control	679	703	597	615
	No spray - Flower buds removed	438	452	415	423
	" - Control	534	531	432	470
Dixie Runner	Spray - Flower buds removed	262	283	273	299
	" - Control	322	366	329	384
	No spray - Flower buds removed	390	400	384	412
	" - Control	405	451	397	471
LSD .05		182	170	47	33

Table 7. Analysis of variance for the effect of fungicidal spray and removal of flower buds on the pod yield for two harvests of three peanut cultivars in 1979 and 1980.

Source of Variation	df	Mean Squares 1979 Harvests First	Second	1980 Harvests First	Second
Spray regimes (S)	1	268,667	280,923	203,685	214,508
Replications	6	109,077**	105,741**	34,766**	38,424**
Reproductive treatments (T)	5	150,153**	133,037**	93,322**	86,822**
S x T	5	98,478**	93,366**	76,085**	80,923**
Error	30	28,775	25,688	1,249	1,051

* Significant at the 0.05 level of probability.

** Significant at the 0.01 level of probability.

Yields of the first harvest in 1979 ranged from a high of 830 grams for Early Bunch with uncontrolled flowering in the sprayed block to a low of 170 grams per plot with controlled flowering in the unsprayed block. Bud removal significantly ($P<0.05$) reduced the yield of Early Bunch in both the sprayed and unsprayed blocks. The yield of Florunner and Dixie Runner was not significantly reduced by controlling reproductive efficiency during the initial flowering period. The yields of Early Bunch and Florunner were higher in the sprayed than in the unsprayed block while the yields of Dixie Runner were greater in the unsprayed.

The second harvest, made 15 days after the initial harvest of each cultivar, was very similar to the first. The yields of Early Bunch were slightly reduced or the same as (-10 to +4 grams per plot) the first harvest. Florunner and Dixie Runner showed increased yields per plot, -3 to +24 grams and 10 to 46 grams, respectively.

Yields of the 1980 harvest followed the same trends as the 1979 harvest. Early Bunch again had the highest and lowest yielding treatments in the first harvest of 792 grams and 212 grams per plot. In the sprayed block the plots with controlled reproductive efficiency had a significantly ($P<0.05$) lower yield than plots with unrestricted flowering. Early Bunch also showed significant differences between reproductive treatments in the unsprayed block, while the other cultivars had no significant differences.

In the second harvest Early Bunch showed slight increases (11 to 15 grams per plot) in yield for all treatments except the controlled reproductive efficiency treatment in the unsprayed block which remained

the same. All treatments of Florunner had greater yields (8 to 56 grams per plot) than at the first harvest. Yields of the Dixie Runner treatments also increased (28 to 74 grams per plot) from the first harvest.

The percent sound mature kernels (SMK) (Table 8) show that Florunner and Dixie Runner had a higher percent SMK than Early Bunch. Data were very consistent from year to year. Early Bunch showed the only significant ($P<0.05$) decrease in percent SMK of the plots with controlled flowering (63 to 55). Fungicidal spray reduced the SMK percentage of Florunner and Dixie Runner from 82 to 74 and 74 to 72 percent, respectively, where reproductive efficiency was controlled. A significant treatment variation and spray regime by reproductive treatment interaction.

Computing the SMK yield per hectare (Table 10), one of the more important factors in commercial production, shows that Early Bunch with uncontrolled flowering had the highest yield of all treatments, ranging from 3900 to 4000 kg/hectare (3471 to 3560 lb/acre). The yield was consistently higher, although no significantly so in every case. The second highest yielding treatment was Florunner with unrestricted reproductive efficiency ranging from 3200 to 3800 kg/hectare. There was little difference between the SMK yields of the two reproductive treatments of either Florunner or Dixie Runner within a block. Only the unsprayed plots of Dixie Runner in the second harvest of 1980 shows significant ($P<0.05$) differences.

Table 8. Mean effect of fungicidal spray and removal of flower buds on the percent of sound mature kernels for two harvests of three peanut cultivars in 1979 and 1980.

Cultivar	Treatment	1979 Harvests		1980 Harvests	
		First	Second	First	Second
Early Bunch	Spray - Buds removed	61.4	65.5	65.2	65.6
	" - Control	67.0	65.0	69.3	67.3
	No spray - Buds removed	39.5	51.2	60.1	58.4
	" - Control	62.0	62.8	63.4	64.4
Florunner	Spray - Buds removed	73.8	74.3	74.3	75.8
	" - Control	74.3	74.5	74.8	75.7
	No spray - Buds removed	81.7	81.5	82.0	83.7
	" - Control	74.3	74.9	74.5	75.6
Dixie Runner	Spray - Buds removed	73.8	70.5	71.5	71.2
	" - Control	73.1	73.0	74.2	73.9
	No spray - Buds removed	74.4	73.8	75.3	74.9
	" - Control	72.3	72.2	73.1	73.5
LSD .05		6.0	6.9	3.9	1.6

Table 9. Analysis of variance for the effects of fungicidal spray and removal of flower buds on the percent of sound mature kernels for two harvests of three peanut cultivars in 1979 and 1980.

Source of Variation	df	Mean Squares			
		1979 Harvests		1980 Harvests	
		First	Second	First	Second
Spray regimes (S)	1	81.6	13.9	0.3	0.3
Replications within spray regimes	6	20.3	16.3	0.8	0.5
Reproductive treatments (T)	5	790.0**	431.6**	227.6**	343.3**
S x T	5	216.6**	106.3**	54.2**	54.5**
Error	30	18.6	25.6	7.5	1.3

* Significant at the 0.05 level of probability.

** Significant at the 0.01 level of probability.

Table 10. Mean effect of fungicidal spray and removal of flower buds on the yield of sound mature kernels (kg/hectare) for two harvests on three peanut cultivars in 1979 and 1980.

Cultivar	Treatment	1979 Harvests		1980 Harvests	
		First	Second	First	Second
Early Bunch	Spray - Flower buds removed	2425	2612	2502	2570
	" - Control	4025	3837	3947	3909
	No spray - Flower buds removed	477	656	917	885
	" - Control	2000	1985	1971	2064
Florunner	Spray - Flower buds removed	3325	3420	3126	3355
	" - Control	3627	3774	3213	3181
	No spray - Flower buds removed	2580	2653	2447	2550
	" - Control	2853	2852	2315	2556
Dixie Runner	Spray - Flower buds removed	1327	1432	1407	1531
	" - Control	1679	1887	1759	2043
	No spray - Flower buds removed	2080	2127	2077	2221
	" - Control	2180	2342	2088	2488
LSD .05		902	838	283	188

Table 11. Analysis of variance for the effects of fungicidal spray and removal of flower buds on the yield of sound mature kernels for two harvests of three peanut cultivars in 1979 and 1980.

Source of Variation	df	Mean Squares			
		1979 Harvests		1980 Harvests	
		First	Second	First	Second
Spray regimes (S)	1	6,191,243	6,303,586	5,711,130	4,878,150
Replications within spray regimes	6	2,706,989**	2,641,060**	987,799**	879,199**
Reproductive treatments (T)	5	4,839,944**	4,045,710**	2,699,039**	2,562,007**
S x T	5	2,680,914**	2,493,422**	2,090,921**	2,208,356**
Error	30	727,301	657,142	45,802	30,260

* Significant at the 0.05 level of probability.

** Significant at the 0.01 level of probability.

DISCUSSION

The mechanical restraints on performing these experiments necessitated sampling only five plants per replication for leafspot disease ratings and yield. However, even under these conditions many of the treatment differences were large enough to be statistically significant. The plants which were handled in the process of removing the floral buds were smaller than plants which did not have the flowers removed. This effect has been reported elsewhere (Williams et al., 1975). How this response may have affected the results was not determined.

In these experiments, as reported in other studies (Nath and Kulkarni, 1967; Ramakrishna and Apparao, 1968), the leafspot diseases appeared in the field when the plants had begun flowering. *Cercospora arachidicola*, in agreement with its common name "early leafspot," produced the first lesions. This pathogen produced few lesions in both 1979 and 1980, and *C. personatum* was the predominant pathogen.

Cercosporidium personatum began to produce lesions about midseason on all plots. In 1979 visual differences between treatments were not apparent for several weeks. Between 14 to 21 days after lesions were initially seen, the plots in the unsprayed block began to show differences between the cultivars and between the flower removal treatments. The foliage of Early Bunch with uncontrolled reproductive efficiency became increasingly lighter green and the

numbers of lesions were noticeably higher than on the other cultivars. Plots with controlled reproductive efficiency had fewer lesions than those with unrestricted flowering for all three cultivars.

Differences in disease ratings increased until prior to harvest when leaf abscision resulted in yet another difference between the treatments. The cultivars with uncontrolled flowering shed different amounts of their leaves. Early Bunch lost the most leaves followed by Florunner, while Dixie Runner showed little leaf loss. Plots in which initial floral buds were removed retained more leaves than their counterparts with unrestricted flowering. As the plants matured the amount of leaf loss in plots with controlled flowering, while much less than that of the other plots, was greater for Early Bunch and Florunner than for Dixie Runner.

In 1980, counts of leafspot lesions showed that fungicical sprays delayed the incidence of disease. About the same number of lesions were produced on all three cultivars through the first 100 days of growth. Cultivar differences then became apparent. Early Bunch, the highest yielding and earliest maturing cultivar, developed large numbers of lesions on plots which had unrestricted flowering. The number of lesions per plot for Florunner and Dixie Runner also had increased but to a lesser degree. Plots of Early Bunch which had the initial floral buds removed had similar numbers of lesions to the lower yielding cultivars.

At the last sampling date in the sprayed plots, both treatments of Early Bunch had about the same number of lesions as the unsprayed plots indicating that fungal control merely delayed the increase in lesions numbers as reported by Plaut and Berger (1980). In the case of Early Bunch this delay continued until

harvest time which is desired for chemical control of disease. Neither Florunner nor Dixie Runner reached as high numbers of lesions in the sprayed plots, but the number of lesions rapidly increased for these cultivars as well.

In the unsprayed plots lesion numbers showed greater changes and greater differences between treatments. The number of lesions per plot sample increased from a very few to several hundred in a short period of two weeks. Initially, differences between the floral removal treatments of a cultivar were small, but as the number of lesions per plot increased these differences increased. From the first sampling Early Bunch had the largest number of lesions, while Florunner and Dixie Runner had similar numbers through the fourth sampling date. Florunner had rapidly increasing lesion numbers from the fourth to the fifth sampling, whereas Dixie Runner had a gradual increase in lesion numbers.

Plots with unrestricted flowering had a larger number of lesions than the plots with controlled reproductive efficiency after the third sampling for all three cultivars. The difference between the two treatments was greatest in the unsprayed plots. Significant spray regime by reproductive treatment interaction for lesion number confirms that controlling reproductive efficiency had a greater effect on the different cultivars for lesion numbers in the unsprayed than sprayed plots. Sprayed plots of Early Bunch and Florunner with uncontrolled reproductive efficiency had more lesions than the treatments with controlled efficiency in the unsprayed plots. At the last sampling the number of lesions per plot sample indicated a similar trend

for Dixie Runner. The number of lesions increased more for sprayed plots with unrestricted flowering than for unsprayed plots with controlled flowering.

Yields of the three cultivars were as expected in the sprayed block when flowering was allowed to proceed as normal. Early Bunch had a greater yield than Florunner, which outyielded Dixie Runner. Of greater interest are the effects of the different treatments on yield. Early Bunch showed the greatest decrease in yield because of removing the initial floral buds. The yield of Florunner was not significantly reduced by bud removal in the first year's experiment. In the second year slight reductions occurred in the unsprayed plots for both the first and second harvests. Dixie Runner also showed yield differences in the second year's study. Hemsey et al. (1974) found, for the cultivar, Colorado Manfredi, that removing flowers until 40 days after planting increased yields over controls. It is possible in this study that the crucial flowering period for the lower yielding cultivars was late enough in the season that the yields were not greatly reduced by removing floral buds for the period of the treatment.

Yields for the second harvests showed different results in 1979 and 1980. In 1979, plots in which the reproductive efficiency had been controlled, showed the largest increase in yield between the first and second harvest. However, in the second year both reproductive treatments of Florunner and Dixie Runner had greater yields in the second harvest. The increases in 1979 could be explained by greater fruit filling in plots with controlled flowering because of the greater capability for photosynthesis by the remaining leaves

than of the other treatments between harvests. In 1980, the increase in yield for plants with unrestricted flowering may have involved filling a larger number of immature fruit.

Fungicide sprays increased yields of all treatments except those of Dixie Runner. Fungicide sprays reduced the differences in yield between reproductive treatments. Williams et al. (1976) reported that 50% defoliation increased growth rate per pod. Possibly the defoliation that occurred in the unsprayed plots of Dixie Runner resulted in a greater growth rate of the fruit than that in the unsprayed plots.

Removing the initial floral buds had little effect on percent SMK in the sprayed plots. Unsprayed Early Bunch showed a dramatic decrease in percent SMK while Florunner had a moderate increase. The three cultivars showed differing effects from fungicidal sprays for leafspot; SMK's for Early Bunch increased with leafspot control sprays while Florunner, and Dixie Runner to a lesser extent, had a decreased SMK percentage. The latter had been noted before (Backman et al., 1977) and is thought to involve an imbalance of the soil pathogens and antagonistic fungi and bacteria. From the SMK yield data we see that Early Bunch shows a significant decrease when buds are removed and plots not sprayed. Dixie Runner showed a similar response to bud removal in the second year while Florunner only showed a response to leafspot control for SMK yield. These results may be related to the effect of bud removal on pod yield.

Considering both yield and the amount of leafspot, the data show that with lower yields the numbers of leafspot lesions are also lower prior to maturity. Early Bunch which exhibited the greatest decrease in yield from controlling the reproductive efficiency also had the

largest differences in leaf retention ratings (1979) and lesion numbers (1980). Shortly after physiological maturity little difference was seen between the reproductive treatments of Early Bunch. Dixie Runner which has smaller yield differences between reproductive treatments also showed the least effect on leafspot disease.

Nevill and Evans (1980) performed a study in which flowers were removed after the initial three weeks of flowering. They reported no decrease in leafspot, and suggested that reports of resistance to leafspot diseases in conjunction with low yield was related to a greater number of leaves. Thus, they stated that a random leaf sample would indicate a smaller number of lesions or less disease but would not actually be greater resistance. Williams et al. (1976) found in the cultivars he studied that removing pods did not significantly increase plant growth rate. This study indicated that decreasing the yield, or at the least removal of the initial flowers does indeed increase leafspot disease resistance or delay the most severe effects of leafspot disease.

An important difference between these studies involving flower removal and those of Nevill and Evans is that they allowed flowering to proceed for three weeks at a time when plants were very small. At this time the new fruit require a larger proportion of the photosynthate produced by the plant than later in the season. In this study flower buds were removed for the initial 48 to 60 days of flowering, and this allowed the plants to mature to a greater extent before the fruit began forming a large sink for photosynthate and other nutrients. This may be the major reason for the different results obtained from the two investigations.

SUMMARY AND CONCLUSIONS

The objective of the studies reported in this dissertation was to determine the effects of yield and maturity on the susceptibility of three peanut cultivars to leafspot diseases. The three cultivars, Early Bunch, Florunner, and Dixie Runner differed in yield and maturity. Early Bunch, the highest yielding cultivar matures earliest. Florunner and Dixie Runner are moderately high yielding and low yielding, respectively, with Dixie Runner maturing latest of the three cultivars.

Each cultivar was subjected to two treatments, one in which the reproductive efficiency was allowed to remain as normal and the second in which initial flowering was restricted. The second treatment was to reduce the yield and did so significantly in Early Bunch. Florunner and Dixie Runner, however, showed slight yield reduction because of bud removal. The two higher yielding cultivars showed significant reductions in disease measurements when flower buds were removed, whereas Dixie Runner had about the same amount of disease in plots with either controlled or uncontrolled reproductive efficiency.

Leaf abscision or plant maturity was delayed by removing the initial reproductive organs. The differences between reproductive treatments increased as pathogen numbers increased. Lesion numbers increased for all treatments and from indications based on Early Bunch eventually reach a maximum for all treatments.

In addition to the reproductive treatments the experiment was grown in two blocks, one of which received leafspot control. The results of restricted and nonrestricted flowering followed the same trends in both blocks. Early Bunch showed the greatest effect from controlling reproductive efficiency and leafspot diseases. Dixie Runner had higher yields in the unsprayed plots.

The results from this experiment indicate that reducing the initial fruiting of peanut plants will reduce the amount of leafspot occurring and delay plant maturity. They also indicate that cultivars respond differently to flower removal relative to yield and to leafspot control.

Further study could show how long fruiting must be delayed to get a reduction in disease. Also, a study of this type could indicate at what point higher yielding cultivars begin to lose yield. Additionally the possibility of using photoperiod responses to develop lines which flower later and thereby reducing leafspot diseases, may be worth examining.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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